Numerical characterization of Nano composites with graded interphase distribution round spherical inclusion.

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Abstract :

The duct work in this study focuses on numerical modeling of the mechanical properties of a nanocomposite (Polyamide / silica) under uniaxial stress. The discretization of effect of the interphase was investigated by varying the number of under layer 20 up to the results obtained show the variation of the stiffness with various parameters. The results and various analysis have been obtained using the ABAQUS finite element code.

Keyword: nanocomposite, finite element method, interphase.

1 Introduction

The introduction of nanofiller in polymeric matrices is developed and producing improvements in mechanical properties of the synthesized materials, among others the rigidity and the elastic limit, which makes it interesting materials. The special nanocomposite systems make the phenomena occurring on the surface play a predominant role in the macroscopic mechanical behavior of the material. An area around the reinforcements called interphase, the subject of a lot of work to understand its nature, its thickness and its reach within the samples. Today, the experimental challenge is to differentiate the mechanisms behind the building. Therefore, for this, synthesizing systems through modeling that can be viewed on a platform of a research called ABAQUS code.

2 Stiffness of Interphase:

The interphase modulus must is given with the following equation:
Where *Ep*, *Em* and *Ei* are respectively the elastic modulus of the nanoparticle, the matrix and the interphase, ri is radius positioning the sub layer (rp < ri < rm).

$$(E_i)_i = \frac{r_m}{r_i} E_m + \left(\frac{r_m - r_i}{e}\right)^{\beta} \left(E_p - \frac{r_m}{r_p} E_m\right).$$

Where β : the coefficient of specific adhesion between the matrix and the reinforcement.

2.1 Effect of Particle Size

Nanometric particles of silica surrounding the diameters 20nm to 60nm, in a volume fraction of 5% with a thickness of 20nm interphase, the number of discrete sub-layers is 10, there are the best mechanical properties of the resulting material inclusions of small sizes. However, the growth in size for such considerations, only weakens the properties and for the different modes of adhesion of the two phases.

2.2 effect of the volume fraction

To confirm what has been stated above, as to the positive effect of the thickness of the interphase on the properties of the material for a given size of inclusion. We tried to see the effect of the volume fraction on mechanical properties for the different qualities of membership between the two phases.

2.3 Effect of Thickness and Sub-layers of Interphase

For a fixed size of the particle Rp to 20nm in a volume fraction of 5%. The growth of the thickness of the interphase directly contributes to increasing the rigidity for different β coefficients. Note the more dramatic was deduced is improving the rigidity depending on the number of sub layers of discretized interphase , the interphase was subdivided into five , then ten , and finally twenty sub-layers. We note that the adhesion of the matrix to the particles described by the low values of the coefficient β (β = 0.01, β = 0.1, β = 1) markedly improves the properties of the material for one of increasing thicknesses of the interphase favoured by good charge transfer between the matrix and the reinforcements.

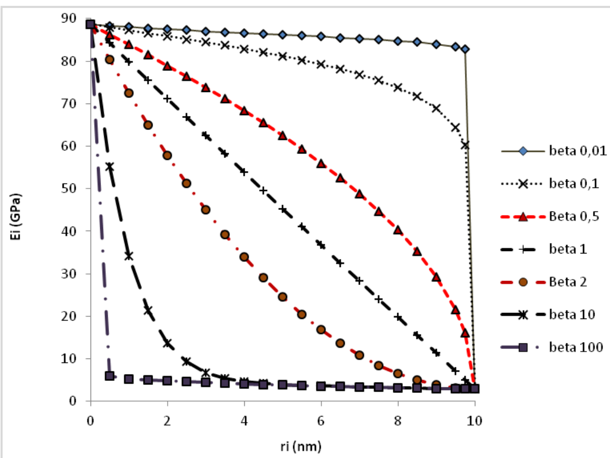
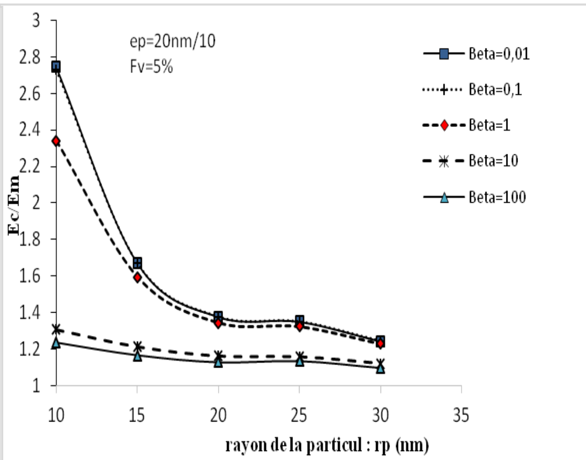


Figure. 2 : effect of the β coefficient of elastic modulus of the interphase



Figures.2.1: effect of particle size with interphase discretized into 10 sublayers.

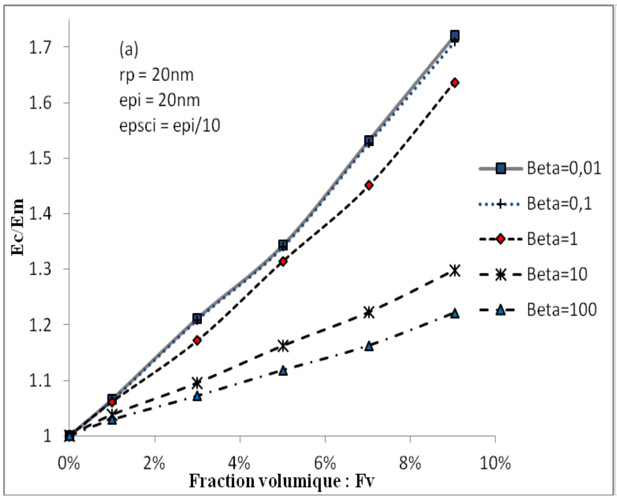


Figure.2.2: effect of volume fraction with discretized Interphase into 10 sub-layers.

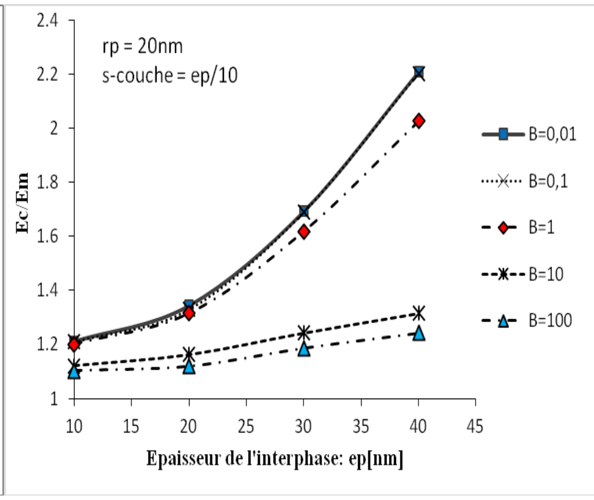


Figure.2.3: effect of interphase thickness and discretized Interphase into 10 sub-layers.

3. Conclusion

The objective of this work was to study the mechanisms of strengthening effects observed in the nanocomposite materials. For this numerical model system, the nanoparticles have been developed with interphase discretized into sub-layers. The mechanical properties of these materials were analyzed. The characterizations of the nanocomposite studied showed a significant change of Young's modulus for a discretization of the interphase with ABAQUS code. We note some agreement either in increasing or decreasing trend of the module with parameters (Rp, ep, β, and Vf number of sub layers). From the increase in the number of sub-layers, it was confirmed the range of effective and usable size of the silica particle.

Reference

[1] Y. Liu, H. Cong, W. Wang, C. Sun, and H. Cheng. A nanoparticle-reinforced nanocrystalline al matrix composites: Fabrication and mechanical properties. Materials Science and Engineering A, vol. 505 :pp. 151–156, 2009.

[2] A.Usuki, Y.Kojima, M. Kawasumi, "Synthesis of nylon 6-clay hybrid". Journal of Material Res, Vol.8 (5), pp. 1179-1184, 1993.

[3] E. Chabert et al. "Prediction of the elastic response of polymer based nanocomposites: a mean field approach and a discrete simulation". À Lyon, France en date 29/11/2002.

[4] Emmanuelle Chabert, « Propriétés mécanique de nanocomposites à matrice polymére : approche expérimentale et modélisation », INSA de Lyon, en 2002

[5]Sandrine Marceau, « Architecture multi échelle et propriétés mécanique de nanocomposites », Université de Savoie en 2003.